# Predatory Species in the Tracy Fish Collection Facility Secondary System: An Analysis of Density, Distribution, and Diet

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## Summary

The U.S. Bureau of Reclamation's (Reclamation) Tracy Fish Collection Facility (TFCF), located in California's Sacramento-San Joaquin Delta (SSJD), is intended to divert and salvage fish to prevent them from entering the Delta-Mendota Canal, thereby minimizing fish entrainment and pump induced mortality at Reclamation's downstream Bill Jones Pumping Plant. To comply with the Biological Opinion, Reclamation is required to reduce the impact of predator fish present at the TFCF in order to achieve the highest fish salvage efficiency possible within present day operations and original design limitations. Similarly, Reclamation employees are required to conduct research in an attempt to continually improve fish salvage efficiency. There are a number of factors (*i.e.*, water velocity, diel period and bypass ratio) that affect fish salvage efficiency at the TFCF (Bowen *et al.* 1998, Sutphin and Bridges 2008). Predation has long been understood to contribute to significant loss of salvageable fish at the TFCF (Orsi 1967, Liston *et al.* 1994, Fausch 2000), and therefore contributes to unnatural declines (declines that would not occur in the absence of man-made infrastructure) in abundances of native, threatened or endangered species including, but not limited to, delta smelt (*Hypomesus transpacificus*), Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and Sacramento splittail (*Pogonichthys macrolepidotus*).

Anecdotal evidence suggests predatory fish accumulate and reside throughout all major components of the facility, including in front of the trash boom and trashrack, the

primary channel, primary bypass tubes and the secondary channel. Nonresident predators are often observed in the holding tank, count bucket, haul bucket, and within the TFCF haul trucks. Predation loss at the TFCF is a major concern and Reclamation biologists have focused significant research efforts in this area, and continue to develop research to improve predator removal efficiency and personnel safety during such operations. Currently, the primary means by which TFCF employees attempt to improve fish salvage efficiency and minimize fish loss due to predation are regularly scheduled predator removals in the facilities secondary channel, which constitutes halting flow of water from the TFCF primary channel, reducing water volume in the secondary channel, flushing each bypass tube with a short duration (<30 s) burst of a high velocity of water, then seining and netting all remaining fish from other components. High densities of predators tend to accumulate in the secondary channel and this is the most safely accessible area of the TFCF prior to fish collection in holding tanks. However, to date there have been no studies completed to assess the impacts of predatory fish in the secondary system or to determine the effectiveness of current predator removal techniques.

Between 2004 and 2006, Reclamation biologists conducted research to determine seasonal abundance, species composition, and effects of piscivores in the TFCF secondary system on salvageable fish. This research included bi-weekly predator removals from six major areas of the secondary system (*e.g.*, bypasses 1, 2, 3, and 4, pre-louver and post-louver) and a subsequent diet study of 30 randomly selected fish of each species collected within three size classes (<100, 101–200, >200) after each bi-weekly predator removal. As a supplement to this research, and to determine the effectiveness of current TFCF predator removal techniques, four predator removals were conducted over four consecutive hours on three separate occasions (June, September, February), followed by four consecutive days of single predator removal efforts.

As was outlined in the original study design, August 2006 marked two full years of predator sampling in the secondary system and completion of data collection. However, there is still a need for these data to be summarized, analyzed and incorporated in a report.

## Problem Statement

Numerous species of predatory fish reside in the secondary channel which may account for a significant loss of salvageable fish and pose a threat to species of special concern. Measuring seasonal abundance, species composition, predatory diet, and effects of piscivores in the TFCF secondary channel is necessary to understanding the overall impact of predatory fish at the TFCF. Determining the effectiveness of current TFCF predator removal operations will provide an understanding of the importance of continuing efforts to develop new predator removal techniques at the TFCF.

## Goals and Hypotheses

*Goals:*

1. Determine if season, water temperature, tide level, secondary channel water velocity or density of fish moving through the TFCF affect abundance of predatory fish in the TFCF secondary channel.

2. Determine if season, water temperature, tide level, secondary channel water velocity or density of fish moving through the TFCF affect the distribution, as a function of bypass tube and major components, of predatory fish in the TFCF secondary system.

3. Determine if season, water temperature, tide level, secondary channel water velocity or density (and species) of fish moving through the TFCF affect the diet of predatory fish in the TFCF secondary system.

4. Determine the efficiency of current TFCF predator removal techniques.

*Hypotheses:*

1. Season (month), temperature (°C), tide, water velocity in the secondary channel, and estimated density of fish moving through the TFCF have no affect on the abundance of predatory fish in the TFCF secondary channel.

2. Season (month), temperature (°C), tide, water velocity in the secondary channel, and estimated density of fish moving through the TFCF have no affect on the distribution of predatory fish in the TFCF secondary channel.

3. Season (month), temperature (°C), tide, water velocity in the secondary channel, and estimated density of fish moving through the TFCF have no affect on the diet of predatory fish in the TFCF secondary channel.

4. There is no difference in predatory fish diet, as a function of species and size class, compared to species and size classes of fish recorded in the TFCF fish salvage.

## Materials and Methods

Bi-weekly predator removals in the secondary system were conducted from June 2004 to July 2006. Date, time of day, tide level, water temperature and length in time of sampling effort were recorded (at least 30 seconds of "flushing" each bypass). Total weights (kg) were obtained for each of the six sampling sites: Pre-Louver, Post Louver, Bypass 1, Bypass 2, Bypass 3, and Bypass 4. All fish were measured (mm FL).

For the diet study, the first 30 of each species (randomly selected) within three given size classes (<100, 101-200, >200) were euthanized (MS222). Fork length (mm), weight (g) and maximum girth (mm) were recorded. Diet contents were removed from all euthanized fish: (1) fish were identified down to species and standard length recorded and (2) invertebrates were identified to genus and no measurements were taken (only presence and absence). Partially digested fish species were identified by J. Wang or R. Reyes to nearest genus possible.

Data collection for this project was completed in August of 2006. Therefore, future development of a thorough experimental design is no longer necessary to achieve the goals of this research. Similarly, no additional materials are required.

*Data Analyses*

Predator composition will be summarized depending on location of secondary sampling site and through time. To determine if significant differences in predator removal exist between locations, one-way ANOVA (Analysis of Variance) will be conducted if the data is normally distributed. To determine if location makes a difference in predator abundance, a simple graph will be plotted to see the relationship between total predators and secondary location. Fish salvage, secondary velocity, temperature, and time of year will be plotted to see its influence in predator abundance in the secondaries. Weight-length relationships for each predatory species will be plotted. If time permits, striped bass weight-length relations will be compared with other studies conducted recently (*e.g.*, Bulak *et al.* 1995, Tucker *et al.* 1998).

To determine the efficiency of our current method for removing predators, predator removals were conducted on four consecutive hours (8 am, 9 am, 10 am and 11 am). The following three days after this effort, we conducted standard predator removals (no diet analysis). This provided insight as to how long it takes for a population of predators to re-establish in the secondary system. Regression showing predator abundance and days after removal will be plotted.

Diet composition can be measured using percentage by number, weight, and frequency of occurrence (*i.e.*, the % of stomach with food that contains a particular prey type). Each measure of diet composition has strengths and weaknesses (Hyslop 1980, Bowen 1983). In this study, we want to measure the contribution of prey to the predator's nutrition and also the uniformity with which the predators select their diet; therefore, we will use percentage by weight and frequency of occurrence. Weight of fish prey can be estimated using recorded standard lengths (we will use fish weight-length relationship obtained from this study). However, weight of invertebrates will not be used since their presence/absence was the only data collected. Diet electivity (Ivlev 1961), a measure of food type utilization, will be measured by using the Index of Relative Importance (IRI). The index will be calculated as:

$$IRI = (PN + PW)PO$$

where PN = prey item's percentage of the total number of prey ingested, PW = prey item's percentage of the total weight of prey ingested, and PO = prey item's percent frequency of occurrence in the sample (modified from Nobriga 1998). Prey items that constitute a larger proportion of the diet than of the available foods (using salvage records) are considered 'preferred'; conversely, those proportionately underrepresented in the diet are 'avoided' (Lechowicz 1982).

The percent empty stomachs and mean stomach fullness (Terry 1977) depending on time of year will be calculated using regression analysis. Mean stomach fullness among the secondary sampling sites will not be compared because stomachs were randomly selected and pooled from the different sites. As fish grow larger, they often select larger prey (Jobling 1994, Gill 2003). A relationship between length of predator and weight of ingested prey will be compared for the three predator size ranges. Diet composition and fish salvage composition will be compared. Bioenergetic modeling (Rice and Cochran 1984, Adams and Breck 1990, Hartman and Margraf 1993) will be implemented to predict striped bass predation (food consumption rates) on delta smelt and Chinook salmon. Finally, frequency of sensitive species in predators' gut will be graphed.

## Coordination and Collaboration

Experimental design and research updates will be provided at requested TTAT and/or CVFFRT meetings. However, primary coordination and collaboration will be between TFCF staff and biologists, the Fisheries and Wildlife Resources Group, SAIC government contractors, and the interagency TTAT.

## Endangered Species Concerns

No ESA listed species will be encountered throughout the remainder of this proposed research.

## Dissemination of Results (Deliverables and Outcomes)

Research updates will be provided and/or presented at regularly scheduled Tracy Technical Advisory Team (TTAT) and Central Valley Fish Facilities Review Team (CVFFRT) meetings. The primary deliverables will be a Tracy Volume Series, as well as a publication in a peer-reviewed scientific journal. However, Posters and/or oral presentations will also be given at appropriate scientific meetings (*e.g.*, CALFED Science Conference, IEP workshops).

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